LASER SPACE WEATHERING OF QUARTZ. J. J. Gillis-Davis[1], M. M. Markley[1], P.G. Lucey[1] J. P. Bradley[2], and H. A. Ishii[2]. [1]University of Hawaii – Manoa, Hawaii Institute of Geophysics and Planetology, 1680 East-West Road, Honolulu, HI 96822, USA. [2]Institute of Geophysics and Planetary Physics, Lawrence Livermore National Laboratory, 7000 East Avenue, Livermore, CA 94550 USA (contact: gillis@higp.hawaii.edu).

Introduction: Low-iron materials on the surfaces of bodies without an atmosphere present a conundrum while at the same time offer a potential deeper understanding of the space weathering process. Space weathering is the term applied to the darkening, reddening, and reduction in depths of absorption bands in optical spectra of planetary surface materials over time [1,2,3]. Nanophase iron particles found on the vapor-deposited rims of lunar soil grains [4] are thought to darken and especially redden the reflectance spectra of lunar soils [5,6]. Our pulsed laser irradiation experiments are devised to systematically examine how low-iron materials like plagioclase space weather.

Specifically, we wish to examine where the iron comes from to produce the nanophase iron blebs observed in patinas that envelop low-iron mineral grains. Is the iron scavenged from the little amount that exists in plagioclase or does it come from an external source? Suggested external sources are admixed iron-bearing minerals (e.g., olivine, pyroxene and ilmenite) or contamination by iron meteorites.

This work presents our data for space weathering of iron-free high-purity quartz that is laser irradiated with and without fine-grain iron metal. The small percentage of added iron is intended to simulate the amount of meteoritic iron contamination found in the lunar regolith [7]. Future work will include different minerals (e.g., plagioclase, ilmenite, and mafic silicates), and additional data sets (e.g., TEM).

Methods: The experimental setup is similar to [8]. Space weathering simulation of impact heating produced by high-velocity dust particles was achieved using the facilities at the University of Hawaii, Manoa (Fig 1.) The laboratory equipment consists of a Continuum Surelite I-20, Nd:YAG (1064 nm), pulsed (20-Hz) laser. The pulse duration was 6±8 ns, which is comparable to the timescale of micrometeorite impacts. The samples were irradiated with 50mJ per pulse**.** Both samples were irradiated for about 2 minutes using a rastered beam. A vacuum of $1–2\times10^{-6}$ torr was achieved using Pfeiffer Hi-cube turbo and roughing pump combination.

Samples irradiated were reagent grade quartz. The quartz power (45-150 μm) was heated for 48 hours at a temperature of 1000°C to drive off as much adsorbed water as possible. Two experiments were run both with 1 g of granular sample. Sample were not pressed into pellets like [8]. The control contained only the pure quartz. While the experimental sample contained 4% by weight of ferrous iron metal, which simulates the estimated fraction of meteorite metal contamination in the lunar soil [6].

Fig 1. Space weathering experiemental set up. Shown in green is the illustrated path of laser, which is redirected of 90° mirror and focused by a 300mm lens. Chamber is 8-inches tall by 10-inches long.

Reflectance spectra of the samples were taken under vacuum before and after irradiation (Fig 2). We measured UVVIS-NIR (0.4-2.5 mm) spectral reflectance using Analytical Spectral Devices Inc. (ASD) FieldSpec® FR spectrometer. The full-width half-max spectral resolution is 3 nm for 350-1000 nm, and 10 nm for 1000-2500 nm. The ASD spectrometer contains three detectors: one 512 element photo diode array for 350-1000 nm, and two thermoelectrically cooled "graded index" extended range InGaAs photo diodes for 1000-1800 nm, and 1800-2500 nm. We used the standard observational geometry with an incidence angle of 0°, and an emission angle of 30° (Fig. 2). Reflectance is measured relative to spectralon standards (99%, 60% and 40%). The 60% and 40% reflectance standard bracket the average reflectance of the ground quartz.

Discussion: The before and after irradiation spectra show a small 1 μm band do to iron and 1.5 μm band to do water vapor, which we assume is airborn water vapor. Laser-irradiated samples showed significant darkening (Fig 3). In addition, darkening of ths sample was much larger in the visible region and near-infrared, out to 1800 nm. Beyond 1800 nm the spectrum remained nearly unchanged. On this basis it appears that large (>10 μm) nanophase iron was produce because the spectrum darken more than redden. Redding has been shown to be the result of small (<10 μm) nanophase iron.

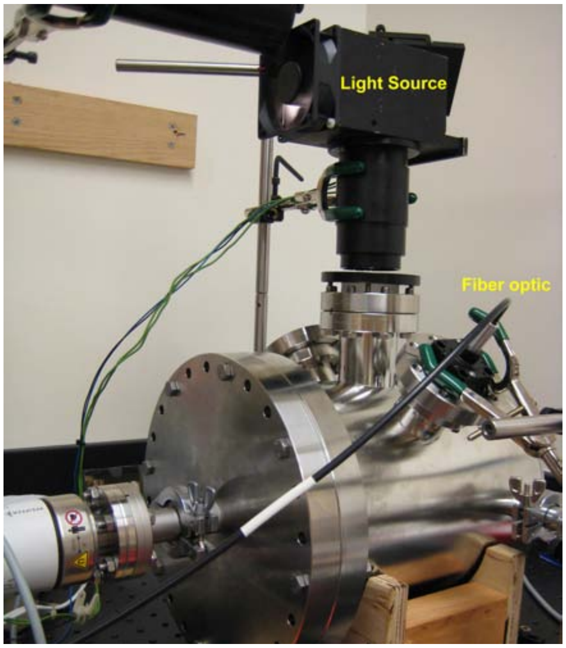

Fig 2. Environment chamber with light source (top) with an incidence angle of 0°, and fiber optic receiving the reflected light with an emission angle of 30°.

Conclusions: Space weathering can occur on surface with low-iron silicates. Meteoritic iron contamination provides sufficient material, while micrometeorites provide sufficient energy for space weathering to occur. Future TEM analyses and experiments will compare the efficiency of micrometeorites to produce nanophase iron from silicates (e.g., olivine and pyroxene) and oxides (e.g., ilmenite), versus iron metal.

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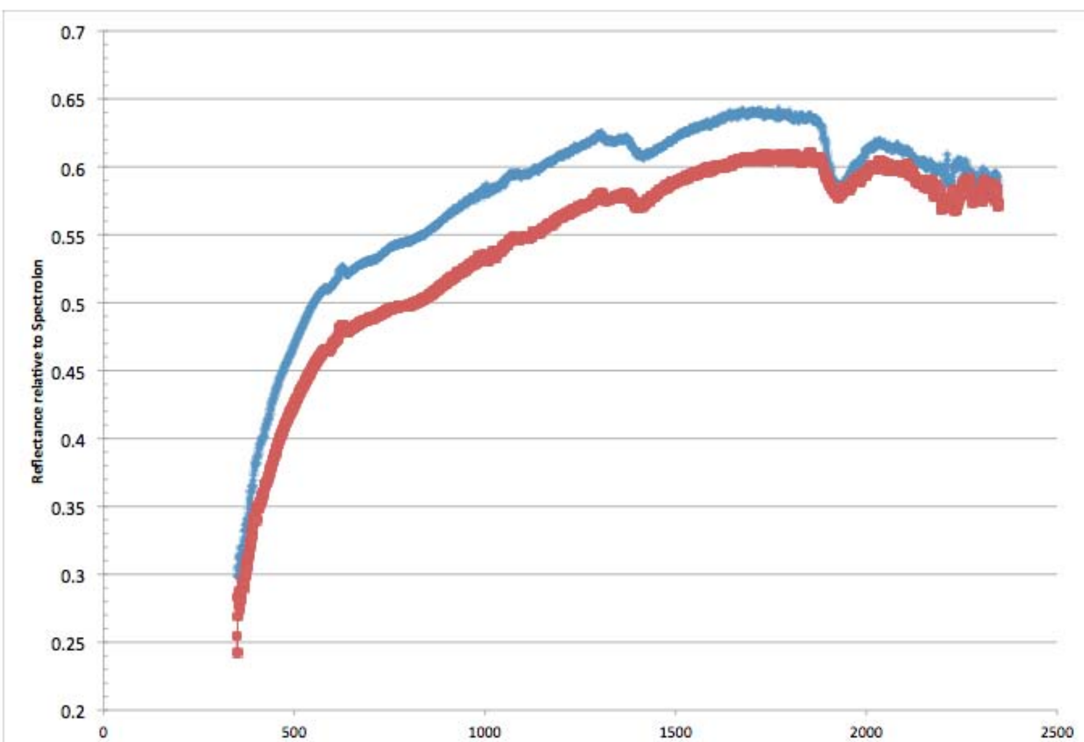

Fig 3. Reflectance spetra of quartz pluse Fe-metal before (blue) and after (red) laser irradiation.